SEISMIC OBSERVATION IN SHIMABARA PENINSULA : ON THE ACTIVITY OF VOLCANO UNZEN

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By

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Abstract

In November 1966, observation of micro-earthquakes was carried out in Shimabara Peninsula on the western part of Kyūshū for investigating seismic activity beneath Volcano Unzen when it is considered to be in the period of quiescence. An earthquake swarm which is presumably of volcanic origin occurred in the same district for three days in July 1966. During our observational period an earthquake sequence just happened to be well observed although its source proved to be quite unexpectedly located. They were aftershocks of a felt earthquake on November 12, 1966. However, no seismic activity was detected from beneath the volcano in two weeks observation so far as the power of resolution of the present observational system goes.

1. Introduction

Historical records describe several aspects of the recent magnificent activities of Volcano Unzen and of relating earthquakes. Lava extrusion is known to have occurred in 1657 and 1792. It took place from a vent 700 m NNE of the summit of Fugendake in the former event, and in the latter lava extruded from a vent 1 km NNE of the summit travelling down a distance of 3 km. In the latter case, forerunning earthquakes started from November 13 of the preceding year increasing its activity until daily number of felt earthquakes reached to as many as about 300 on April 21, 1792, one of which gave considerable damages to houses and properties in the Village of Shimabara 8 km away from the volcano. On May 21, the eastern part of Mae-yama (Mayu-yama) collapsed to cause an avalanche and Tsunami (Kuno [1962]). On December, 8, 1922, this district was attacked by a severe earthquake. Imamura [1925] studied the earthquake. The epicentre determined by use of the seismograms from meteorological stations at Nagasaki, Kumamoto, and Kagoshima was situated at Tachibana Bay 20 km from the volcano.

Since November 26, 1926, Unzen-dake Weather Station seismographs recorded earthquake swarms probably of volcanic origin in the following times (Kuno

〔1962〕).

1929 June, October, and December. 1934 October. 1940 May.
1951 February. 1954 October. 1955 August. 1956 October.

In the year of 1962, Observatory of Kyūshū University started its operation in the City of Shimabara. By analysis of the data obtained at the Observatory, Shimozuru *et al.* 〔1965〕 found that most of the earthquakes which occurred in the period 1962-1964 at Tachibana Bay are considered to be of tectonic nature.

As mentioned above, there have been no eruptive activity of the volcano since 1792 nor big earthquake since 1922 in Shimabara Peninsula. However, it is known that minor earthquake swarms take place from time to time in the area. The last one occurred on July 15 (about four months before this observation) and continued for three days with the maximum intensity of III within the area and with *P-S* time of about 1 second to Unzen-dake Weather Station.

It is an interesting challenge, therefore, to observe whether or not seismic energy is continuously being released under the volcano when it is considered to be dormant in the volcanological sense of the word. Observation of micro-earthquakes was carried out in November for two weeks at the northern part of Shimabara Peninsula.

2. Earthquake swarm in July, 1966

An earthquake swarm occurred in Shimabara Peninsula with a maximum intensity of III in J.M.A. scale and continued for three days from 15 to 17 of July, 1966. The only available data of this earthquake swarm are NS component seismograms obtained by 56 type seismograph at Unzen-dake Weather Station. Numbers of earthquakes per hour read from these seismograms are shown in Fig. 1. According to the figure, it is understood that earthquakes occurred mainly in the short interval of time: in the afternoon of 15 and in the morn-

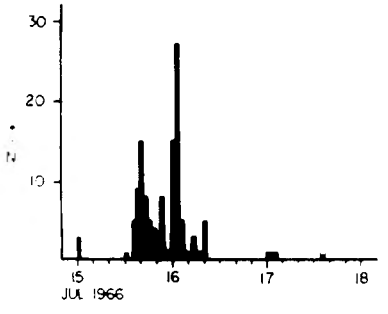

Fig. 1. Hourly frequency of occurrence of the earthquake swarm.

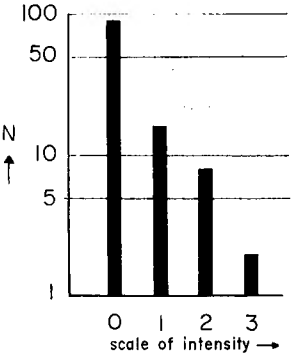

Fig. 2. Intensity distribution of the earthquake swarm in Shimabara Peninsula in July, 1966.

ing of 16 in July. Since July 18, no seismic activity of the area was detected. Shimozuru *et al.* [1967] began seismic observation near the volcano on July 20 (five days after its commencement) finding seismic activity already ceased. The frequency of occurrence is plotted against the seismic intensity at Unzen-dake Weather Station in Fig. 2. The seismic intensity distribution in time was quite random in contrast with the simple pattern of aftershocks, which is characteristic of the volcanic shocks. The most of these earthquakes were with *P–S* times of about 1 second as shown in Fig. 3. It is no doubt, therefore, that this earthquake swarm is of volcanic nature and originated in Volcano Unzen.

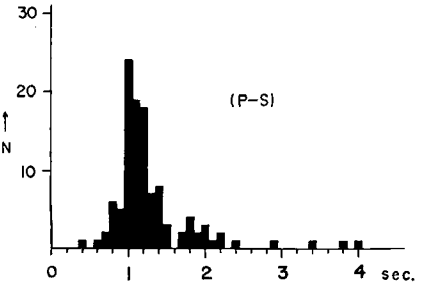

Fig. 3. Distribution of *P–S* times of the earthquake swarm in July, 1966.

3. Observation of micro-earthquakes

Station and technique of the observation

Observation was carried out for two weeks from November 12, 1966 at the northern part of Shimabara Peninsula. The observation station was required to be selected so as that

(a) it is properly distant from Unzen-dake Weater Station and also from the Observatory of Kyūshū University, and

(b) it is based on the preferable geological condition to permit the observations with high sensitivity.

A point was selected at 5 km N of Fugen-dake. (Uoaraigawa, Kunimi-machi, Minamitakagi-gun, Nagasaki-ken. 32°48′N, 130°20′E.) Tripartite technique was used with length of sides of 307 m, 366 m, and 367 m. Signals from electromagnetic transducer of vertical component with free period of 1 second were fed into data recorder through D.C. amplifier. The voltage sensitivity of seismographs is 3.2 volt/kine and the maximum gain of the D.C. amplifier is 60 db. The observation was carried out every night from 23h to 02h when artificial disturbances mainly due to traffic were small.

Observational results

Observed earthquakes are listed in Table 1. *P–S* times, apparent velocity ($\bar{v}$), and azimuth of wave approach are seen to be nearly the same for all the earthquakes observed. On November 12, when the observation started, there occurred a felt earthquake at the northern part of Ariake Sea. The seismic intensity of this earthquake was III at Unzen-dake Weather Station. Judging

Table 1. List of observed earthquakes

Nov. 1966

d		m	s	P–S	$\bar{v}$ km/s	Azimuth	
13	00	17	04.5	2.92	4.1	N02.0E	U
13	01	11	22.0	3.12	4.7	N00.7W	U
13	01	13	15.0	3.48	4.9	N09.3E	D
13	01	24	57.0	3.48	5.2	N11.2E	D
13	01	30	17.5	3.14	5.0	N09.2E	U
13	01	39	31.5	3.56	4.3	N28.3E	D
13	01	42	33.0	2.76	5.1	N09.7E	U
13	23	04	35.0	2.80	5.0	N15.4E	U
13	23	20	17.0	3.52	4.8	N08.7E	U
15	23	06	21.3	3.44	5.2	N07.2E	U
15	23	44	01.3	2.88	4.4	N00.8E	U
15	23	55	11.3	2.84	5.0	N11.1E	U
17	01	03	11.3	—	4.5	N10.6E	U
18	00	33	10.0	2.72	5.1	N14.8E	U
19	23	16	02.5	3.68	4.7	N12.1E	U
20	00	01	01.3	—	4.4	N09.1E	U
21	00	18	46.3	3.08	4.8	N25.0E	U
22	01	06	46.3	3.02	4.9	N25.3E	U
23	23	22	23.8	3.04	3.8	N14.9E	U

from the P–S time and azimuth of wave approach, most of micro-earthquakes observed are considered to be aftershocks of the above-mentioned felt earthquake. According to the meteorological observatory at Fukuoka, the location of the hypocentre of the main shock was φ: 33.1 N, λ: 130.2°E, $H=10$ km. The distribution of initial P motions read from seismograms of several weather stations in Kyūshū is shown in Fig. 4. Our observation point was situated in the domain of compression. The distribution can be attributed to that of quadrant type as shown in the figure. The epicentres of aftershocks determined by use of P–S times and assuming values of 7.0 and 8.0 km/sec for K (Ōmori constant) are plotted in Figs. 5 and 6, respectively. Position of

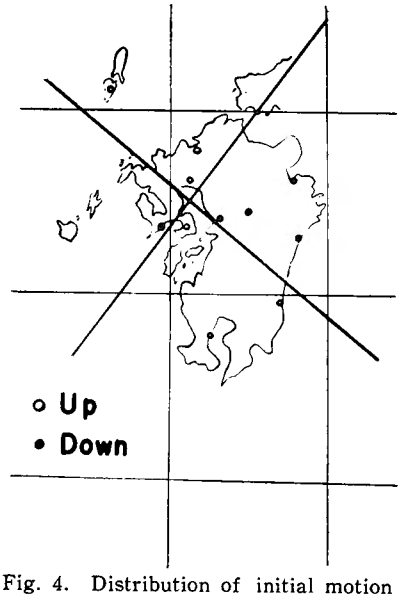

Fig. 4. Distribution of initial motion of the main shock on Nov. 12, 1966.

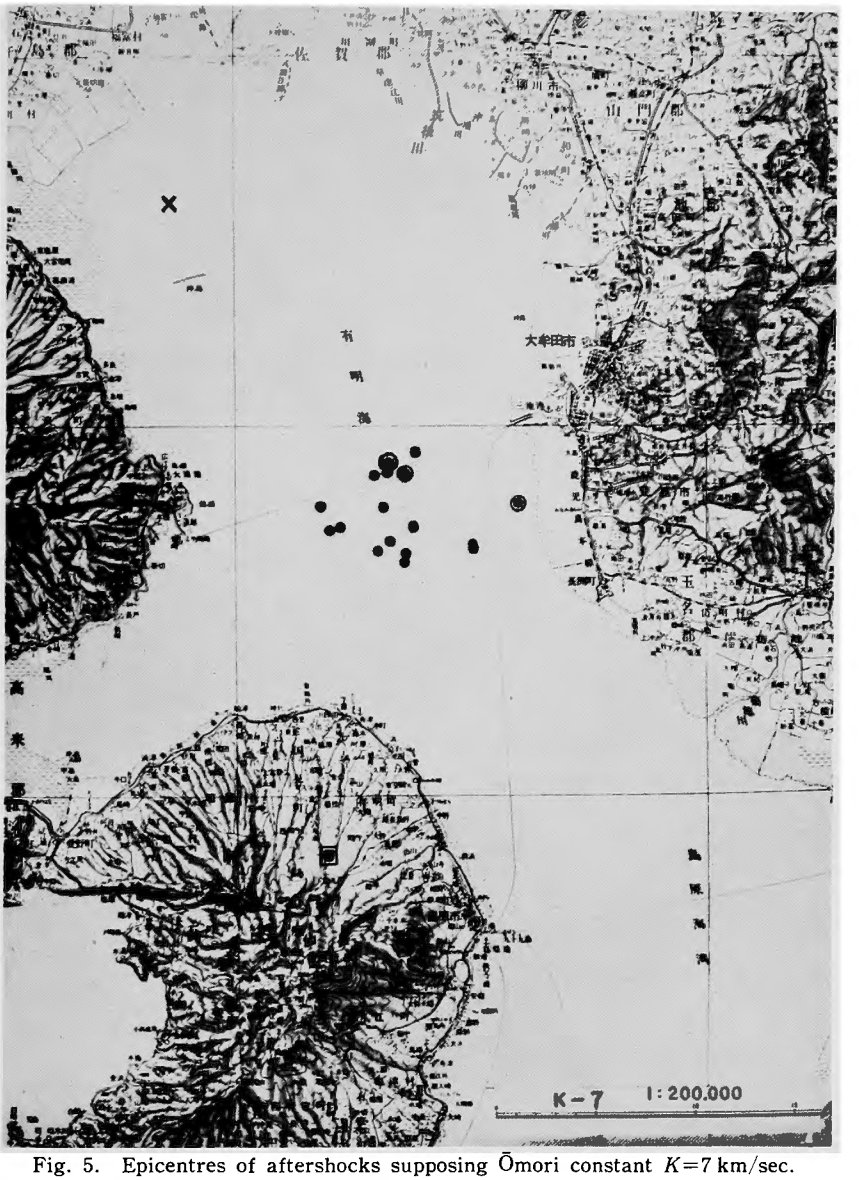

Fig. 5. Epicentres of aftershocks supposing Ōmori constant $K=7$ km/sec.
◉ : Observation station.
× : Main shock.
● : Aftershocks whose initial motion was upward.
⊙ : Aftershocks whose initial motion was downward.

the main shock is also shown in the figures.

Three shocks indicated with double circles are those which showed initial motions of pull at our observation point, suggesting some deviations in the mechanism of occurrence of these shocks from the rest. No notable difference,

Fig. 6. Epicentres of aftershocks supposing Ōmori constant $K=8$ km/sec.

however, could be recognized to exist as regards the epicentral locations. Examples of seismograms are shown in Figs. 7 and 8. Note the clear reversal of initial P motion. It should be stressed that the earthquakes with P-S time of the order of 1 second were completely missing during our observational period. It suggests that seismic activity such as that in July 1966 described above is not of frequent and continuous occurrence.

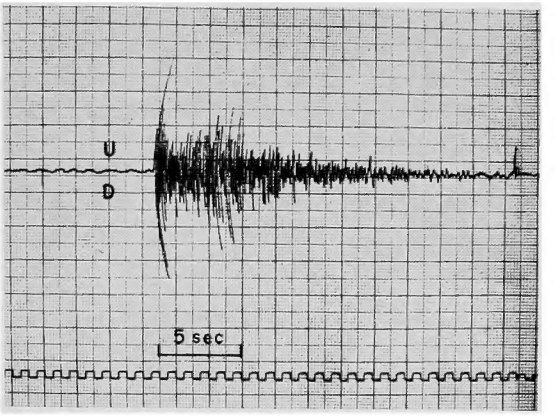

Fig. 7. An example of reproduced record of an earthquake whose initial motion was upward.

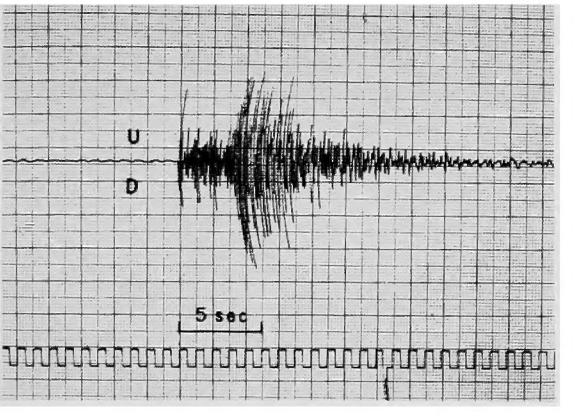

Fig. 8. An example of reproduced record of an earthquake whose initial motion was downward.

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